CHAPTER

12 Cofferdams and Seal Courses

General

A cofferdam is a retaining structure, usually temporary in nature, which is used to support the sides of deep excavations where water is present. These structures generally consist of: (1) vertical sheet piling, (2) a bracing system composed of either wales and struts or prestressed tiebacks, and (3) a bottom seal course if required to seal out water.

Cofferdams are used in situations where adjacent ground must be supported against settlement or slides, and in construction of bridge piers and abutments in relatively shallow water.

Contractor's Responsibility

Cofferdams usually fall under the category of temporary features necessary to construct the work. As such, the Contractor is responsible for the proper design, construction, maintenance and removal of cofferdams. The Contractor is required to submit working drawings to the Engineer for approval in accordance with Sections 5-1.02 and 19-3.03 of the *Standard Specifications*. The Contractor is also required to comply with the applicable sections of the Construction Safety Orders (Section 1811) and the provisions of Section 6705 of the Labor Code.

Engineer's Responsibility

The Engineer is responsible for checking and approving the Contractor's drawings, and for making the decision as to whether a seal course should or should not be used. If the thickness of the seal course is not shown on the plans, the Engineer must determine the thickness of seal course concrete needed.

The Engineer should be familiar with the information in the following sections of the *Standard Specifications*: 5-1.02, 19-3.03, 19-3.04, 51-1.10, 51-1.22; and the following Bridge Construction Memos: 2-9.0 and 130-4.0.

Sheet Piles and Bracing

There are three basic materials used for the construction of sheet piles: wood, concrete, and steel.

Wood sheet piling can consist of a single line of boards or "single-sheet piling" but it is suitable for only comparatively small excavations where there is no serious ground water problem.

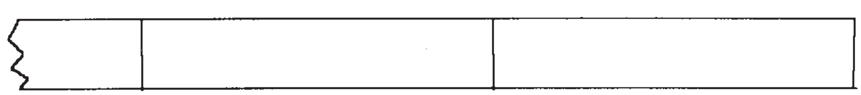

Figure 12-1: Single Sheet Piling

In saturated soils, particularly in sands and gravels, it is necessary to use a more elaborate form of sheet piling which can be made reasonably watertight with overlapping boards spiked or bolted together, such as the "lapped-sheet piling" or "Wakefield" system.

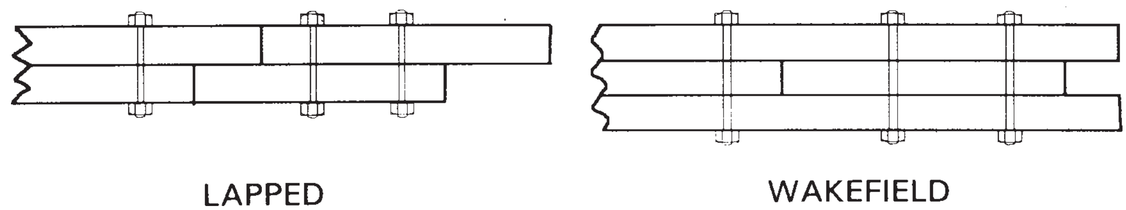

Figure 12-2: Lapped and Wakefield Sheet Piling

"Tongue and groove" sheet piling is also used. This is made from a single piece of timber which is cut at the mill with a tongue and groove shape.

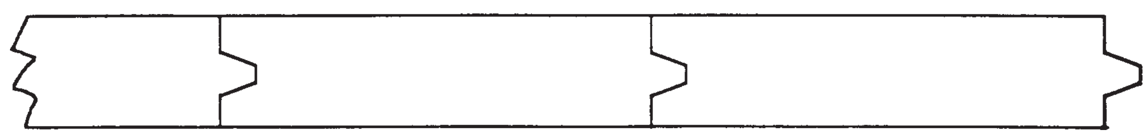

Figure 12-3: Tongue and Groove Wood Sheet Piling

Precast concrete sheet piles are normally used in a situation where the precast members are going to be incorporated into the final structure or are going to remain in place after they fulfill their purpose. For structure work, we normally do not encounter precast sheet piling. Precast concrete sheet piling is usually made in the form of a tongue and groove section. They vary in width from 18 to 24 inches and in thickness from 8 to 24 inches. They are reinforced with vertical bars and hoops in much the same way as precast concrete bearing piles. This type of sheeting is not always perfectly watertight, but the spaces between the piles can be grouted.

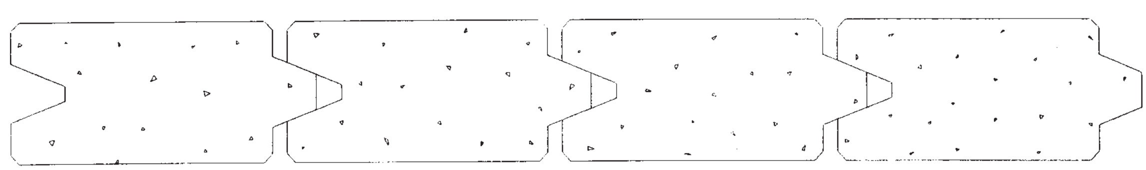

Figure 12-4: Concrete Sheet Piling

In order to provide a more watertight precast concrete sheet pile, two halves of a straight steel web sheet pile, which has been split in half longitudinally, are embedded in the pile.

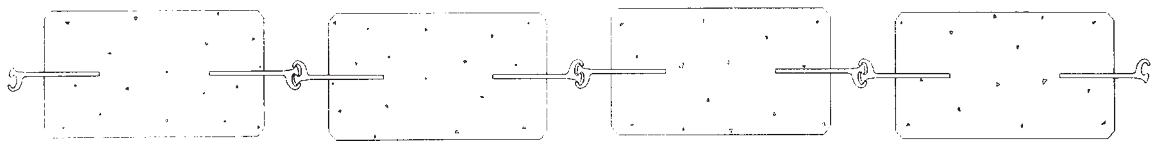

Figure 12-5: Concrete Sheet Piling with Steel Interlocks

Steel sheet piling is most commonly used and is available in a number of different shapes. The shape provides for bending strength and the interlock (connection between sheets) provides for alignment. Each steel company that manufactures sheet piling has its own form of interlock. The simplest shape is that known as the "straight-web" type. These are made in various widths ranging from about 15 to 20 inches. The web thickness varies from about $^3/_8$ to $^1/_2$ inch. The straight-web sheet piling is comparatively flexible and it requires a considerable amount of bracing in areas where the horizontal thrusts are large.

Figure 12-6: Straight Section Steel Sheet Piling

In order to provide a pile with a greater resistance to bending, the steel companies have developed a type known as the "arch-web" section, in which the center of the web is offset so as to provide a greater moment of inertia in the cross section. To provide for even greater stiffness, there is a "deep-arch" section. This is similar to the arch-web except that the offset in the web is increased considerably. A type known as the Z- Section has a stiffness considerably greater than that of the "deep-arch".

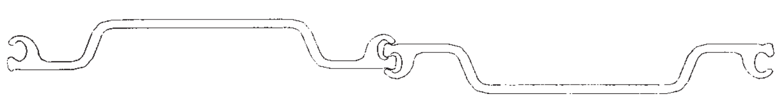

Figure 12-7: Arch-Web Steel Sheet Piling

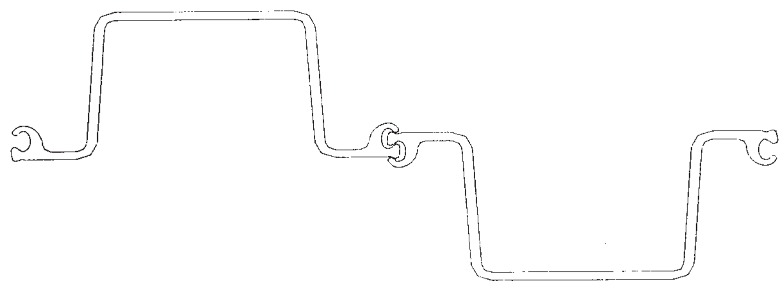

Figure 12-8: Deep-Arch Steel Sheet Piling

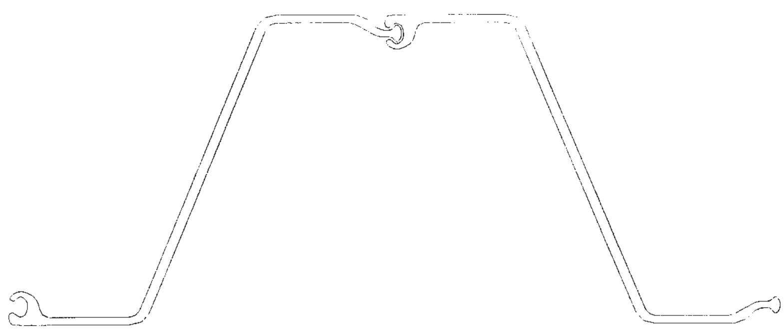

Figure 12-9: Z-Section Steel Sheet Piling

The choice of the type of steel sheet pile to be used on a given job depends largely on the kind of service in which it is intended to be used. The straight-web is comparatively flexible so that it requires a considerable amount of bracing when subject to a large horizontal thrust. However, its size allows it be used in close quarters, where a deep-arch or Z-Section will not fit.

The composition of the bracing system inside the cofferdam will be dependent upon the forces that are present, the availability of materials, and the costs connected with the system. Wood and steel are the normal materials used. Prestressed tiebacks are often used in large land cofferdams where a system of cross-bracing is impractical.

Excavation

Section 19-3.04 of the *Standard Specifications* states, "…that excavations shall be completed to bottom of footings before driving piles". As in many other areas of our work, there are times when engineering judgement should be used depending on type of soil, amount of excavation required, type of pile, and depth below water surface. Normally, excavation would be by submerged clamshell, with the elevations being checked by sounding. In the case of pile foundations, it is often advisable to over-excavate a predetermined amount to compensate for heave of the material caused by pile driving displacement. This is done to eliminate the need for excavation after driving. If excavation is needed, care is required not to damage any of the driven piles.

Seal Course

Following the installation of the cofferdam, the footing can be excavated and piles driven. Usually the footing area must also be dewatered. Depending on the volume of water present, this can be achieved by pumping. Otherwise, a seal course may be necessary. If a seal course is not shown on the contract plans and the Contractor elects to use one to control and remove water from the excavation, the work shall be done in accordance with the provisions of Section 19-3.04 of the *Standard Specifications*.

As the name implies, a properly constructed seal course seals the entire bottom of a cofferdam and prevents subsurface water from entering the cofferdam. In so doing, it permits construction of footings and columns or other facilities in the dry. The seal course is a concrete slab placed underwater and constructed thick enough so that it's weight is sufficient to resist uplift from hydrostatic forces. In terms of it's importance to the designed structure, the seal course normally has no structural significance.

Information pertaining to the seal course for a project may be found in the contract plans. Additional information may be found in the RE Pending File. The decision as to thickness of seal course required, or whether the seal course is to be eliminated, rests with the Structure Representative. This decision is based on conditions encountered on the jobsite. The contract plans will also contain provisions for adjusting footing elevations if seal courses are eliminated. In usual field practice, this decision is not a difficult one to make. In most cases when water is not present the need for a seal course is clearly not there. Additional information about seal courses can be found in Bridge Construction Memo 130-4.0.

Tremie Concrete

Tremie concrete is a name given to the method of placing concrete under water through a pipe or tube, which is called a tremie. The tremie can either be rigid or flexible. Concrete flow can be either by gravity with a hopper located at the top of the pipe, or by direct connection to a concrete pump.

The purpose of this equipment is to enable continuous placement of monolithic concrete underwater without creating turbulence. To accomplish this, it is imperative that the discharge end of the tremie be kept embedded in the concrete. It is also imperative that the concrete have good flow characteristics. Concrete placement can be accomplished by either a tremie supported and maneuvered by a crane or the discharge end of a concrete pump. Frequently contractors will use multiple-tremie systems with each hopper supported by bracing or walkways in the cofferdam. In this case, tremie spacing is controlled by the flow characteristics of the concrete.

Briefly described, a typical tremie operation begins with the tremie pipe being lowered into position with a plug or other device fitted into the pipe as a physical barrier between the water and concrete. Concrete is charged into the pipe to a sufficient height to permit gravity flow. The flow itself is started by slightly lifting the pipe. Once started, the concrete flow must be maintained by continuing to charge the pipe. The operation must continue until completion. The tremie pipe is immersed in concrete during placement. Some factors which assure success for this operation are:

FACTOR	DESCRIPTION
1	Tremie concrete shall have a penetration of between 3 and 4 inches.
2	Concrete shall contain a minimum of 7 sacks of cement per cubic yard.
3	Concrete placement and the maneuvering of the tremie pipe must be done smoothly and deliberately.
4	Concrete delivery must be adequate and timely.
5	The concrete mix design should be geared to good flow characteristics.

Of the various plug devices, the inflated rubber ball is about the most practical. However, a tip plug can cause long tremie pipes to float.

Seal Course Inspection

In addition to the usual pre-pour matters, such as access and suitability or adequacy of equipment, sufficient soundings should be taken to verify elevations. Particular care should be given to the perimeter of the cofferdam and the pile locations. Soundings can be accomplished using a flat plate of suitable size and weight on the end of a rod or rag tape.

This device can be used to not only determine elevations, but, to some extent, can be used to determine the nature of the material (soft or firm). During the pour, soundings are again used to verify the elevation of the top surface of concrete. Because of the type of operation, surface irregularities can be expected, particularly in pile footings. The important thing is to check for proper thickness throughout and the absence of excessive low spots. The *Standard Specifications* require a minimum cure period of 5 days before dewatering.

Thickness of Seal Course

A chart for determination of seal course thickness is included in Appendix I. Certain safeguards or safety factors are built into this chart. For example, seal courses in pile footings are constructed one foot thicker than required to allow for surface irregularities. The bond friction between sheet piling and concrete is disregarded. The bond friction between seal course concrete and foundation piles is limited to 10 Pounds per Square Inch (PSI). Minimum thickness of seal course concrete is 2 feet. This subject is also covered in Bridge Construction Memo 130-4.0 and Bridge Design Aid "Seal Course" included in Appendix I.

Dewatering

Section 51-1.10 of the *Standard Specifications* requires a minimum cure period of 5 days (at concrete temperatures of 45° F or more) before dewatering may begin. Dewatering can present some anxious moments since the cofferdam and the seal course will be put to the test.

Dewatering is sometimes conducted in stages for a moderately deep cofferdam. At each stage intermediate bracing systems are installed before proceeding deeper. Depending on the particular design, these internal braces restore the stability of the system.

A review of contract provisions for water pollution control should be made before dewatering operations start.

Sheet pilings are not watertight and minor leaks can be expected as the cofferdam is dewatered. These leaks occur along the joints between adjacent sheets. Sawdust, cement, or other material can be used to plug these, and this type of leak is ordinarily not a problem. This is usually done by dropping the material into the water adjacent to the leaking sheets. Flow through the leak carries the fine material to the problem area and seals the crack or opening. A sump built into the surface of the seal would be helpful in keeping the work area reasonably dry. Obviously, sumps should be located outside the footing limits.

Prior to proceeding with footing work, all high spots in the seal have to be removed. All scum, laitence, and sediment must also be removed from the top of the seal. This work can be very time consuming and expensive. It can be reduced significantly if care is taken when the seal is placed.

Safety

Cofferdam work presents safety problems unique to this type of construction. Among them are limited access, limited work areas, damp or wet footing, and deep excavations. Provisions must be made for safe access in terms of adequate walkways, rails, ladders, or stairs into and out of the lower levels.

The work may be within a waterway, in which case additional safety regulations may apply. These would include provisions for flotation devices, boats, warning signals, and suitable means for a rapid exit. The Construction Safety Orders should be consulted for specific requirements.